

Smart Phone Electrocardiogram – Bridging the Gap

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Abstract

The latest development in the area of medical technology and telemonitoring has been the smart-phone electrocardiogram. The wide availability of smart phones in India, makes it a potential handheld ECG machine. ECG is highly used investigation in cardiology, with its ability to pick up Acute coronary and arrhythmic events. In this article, we would discuss about two such devices SANKET life, which is made in India and the US FDA approved Kardia ALive Cor device.

Keywords: Coronary artery disease, diagnostic, widespread

INTRODUCTION

The 21st Century has witnessed a paradigm shift in technological advancement and a boom in mobile health technologies. Smartphone applications are becoming very common in the modern management of cardiovascular diseases (CVD). There is increasing emphasis on self-management and the use of mobile applications to improve the quality of health care in case of chronic diseases. The latest integration of technology and modern medicine is the smartphone electrocardiogram (ECG). Much of the first electrocardiograms since its inception by Willem Einthoven were bulky. Recent developments of smartphone devices have led to the miniaturization and integration of ECG into mobile phones. ECG has a wide variety of uses but mainly used for diagnosis of cardiac arrhythmia and myocardial infarction.^[1] In this review article, we will review the available smartphone ECG devices.

Cardiovascular disease in India

CVDs are the leading cause of death in India. Coronary artery disease (CAD) has rapidly increased in the younger and middle-aged population leading to a great loss in productivity. In Western populations, only 23% of CVD deaths occur before the age of 70 years; whereas in India it is around 52%. There has been a rapid epidemiological transition from infectious diseases to noncommunicable disease within a brief time. The overall burden of CVD in India is shown in Table 1.^[2] There have been poorer outcomes in rural areas due to lack of facilities to diagnose CVD in a timely manner.^[2]

Electrocardiogram

The ECG is an essential noninvasive test, used for screening, diagnostic, and monitoring CVD. ECG machines have evolved from the bulky room-sized equipment to now wearable technology at present [Figure 1].

ECG is a highly used and reliable investigation in the field of cardiology, and there is a huge need of ECG in rural areas where even basic facilities may not be available. Hence, there is a drive to make ECG more compact and ubiquitous. The smartphone is an ideal technology that can be made to function like an ECG machine. It has an operating system, internet connection, easy touchscreen interface and has already widespread availability throughout India. In 2013, AliveCor Kardia was the first device in the USA to be FDA approved for recording ECG in medical applications in smartphones. Following that many companies have made their own versions.^[1]

Smartphone electrocardiogram devices

There are many devices available in the market. In India, Alive COR KARDIA, SANKET LIFE are two important medical device apps at present in the market. In the USA, there are other devices namely – ECG CHECK, D-Heart, Qardio Core, EPI Mini, and iHealth Rhythm. These devices operate on the

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same basic principle of a sensor lead which collects the signals and the transmission through Bluetooth or other methods to a smartphone for further data processing.^[1,3] The differences

between the two devices available in India are shown in Table 2. We will be reviewing one of the products Sanket life in this article.

Table 1: Cardiovascular diseases burden in India

CVD spectrum	Death per 100,000 population	
	Male	Female
Ischemic heart disease	178	112
Cerebrovascular disease	90	75
Rheumatic heart disease	11	10
Hypertensive heart disease	18	15
Cardiomyopathy, myocarditis	10	5
Atrial fibrillation	1	1

CVD: Cardiovascular diseases

Size

It is approximately the size of a credit card. It can be easily fitted in the pocket.

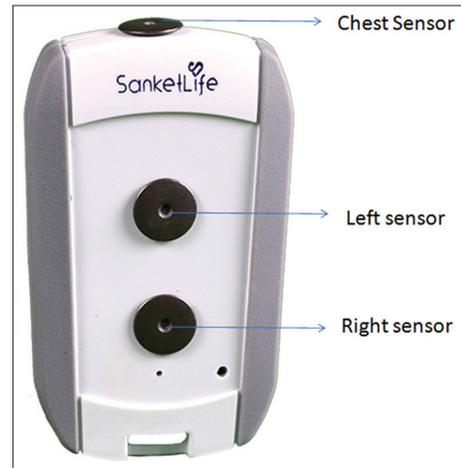


Figure 2: Device showing thumb sensor and chest sensor.

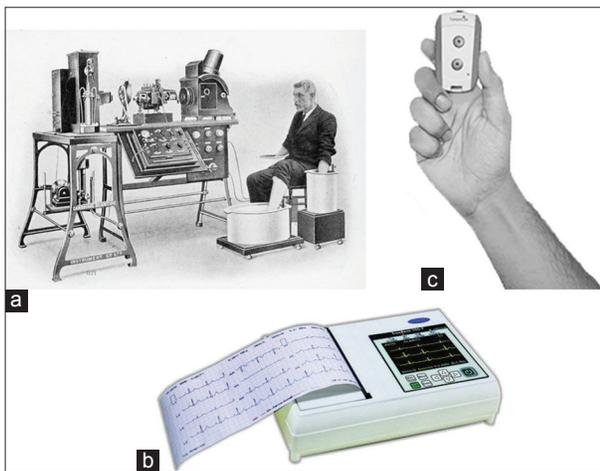


Figure 1: Evolution of electrocardiogram machine – (a) the initial bulky galvanometer device discovered by Einthoven. (b) Conventional modern day portable electrocardiogram machine. (c) Handheld smartphone electrocardiogram device (SANKET LIFE).

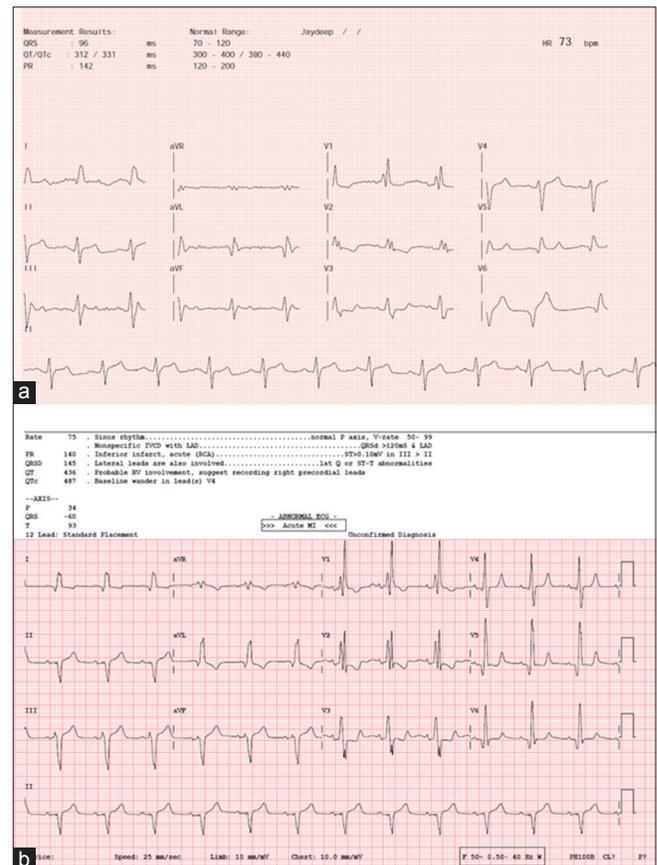


Figure 4: Electrocardiogram obtained as PDF from Sanket life mobile app (a) and the corresponding electrocardiogram (b) from a conventional electrocardiogram machine in a patient with congenital heart disease.

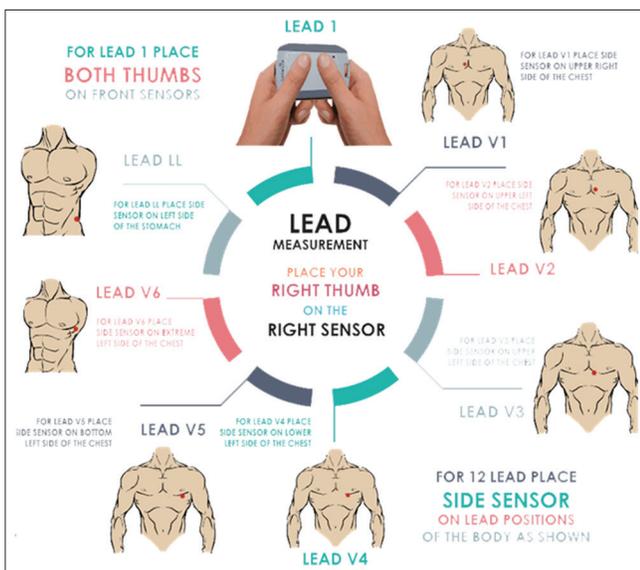


Figure 3: Chest sensor has to be placed in appropriate positions as the conventional precordial electrocardiogram leads.

Table 2: Specifications of the commonly available smartphone electrocardiogram devices

Specifications	Kardia mobile	Sanket life
Size (cm)	8.2×3.2×0.35	7×4×1
Weight (g)	18	25
Power	3v CR2016	3v CR2032
Cost (INR)	15,000/-	5999/-
Transmission	Ultrasound	Bluetooth
Leads	Single lead at a time (can record all 12 leads)	Single lead at a time (can record all 12 leads)
Compatibility	Apple: iPhone 4s/5/5s/5c/SE/6/6s/6 Plus/6s Plus/7/7 Plus, iPod Touch 5G, iPad Air/Air 2/Mini 2/Mini 3 Android: Samsung Galaxy S3/S4/S5/S6/S7/J1, Note 3/Note 5, LG Nexus 5, HTC One M7, Jitterbug touch 3, Google Pixel/Pixel XL	Android v 5.1 and above BLE and iOS 8.2 and above

INR: Indian rupees

Specifications

There are three sensors. Two on the front panel of the device and one on the top to be used as a chest lead sensor [Figure 2].

Battery

The initial battery was chargeable with a USB cable provided, but subsequent designs have a replaceable watch battery inside which can be changed after its use.

12 leads electrocardiogram

Sanket life is able to record the electrical activity of all 12 leads but not synchronously. It has to be obtained serially. However, it does not use jelly or any actual electrodes. The actual procedure to obtain these 12 leads is shown Figure 3.

Interpretation

New algorithms are continuously being added, but the present device is capable of detecting atrial fibrillation and does the measurements of the intervals and segments. The accuracy of the device has to be validated in larger studies.

The PDF report generated is comparable to standard ECG paper, and it can be printed out or texted to the physicians immediately [Figure 4].

Advantages

1. Easy handheld device
2. Reasonable price compared to ALIVE Cor which is valued at Rs. 14000 INR
3. Can be used in the outpatient department, can be used by physician, technicians, and even by patients
4. Works in a leadless wireless fashion
5. Able to get all 12 leads for analysis
6. Reasonable accuracy
7. Stores images in Cloud Drive
8. Able to provide a basic initial report
9. They charge Rs. 175 rupees only for the expert cardiac opinion.

Limitations

1. The accuracy of the device has to be validated. Large studies need to be done with a comparison to a gold standard conventional ECG, before using the device in clinical practice. It has not been tried on pediatric patients,

patients with pacemakers and congenital heart disease patients

2. Although mentioned on their website as being able to take ECG through the shirt, it is not always possible to do so unless the shirt is a very loose piece of cloth. The data obtained from skin surface is better compared to one through the shirt
3. It does not have an inbuilt data processor; you need a mobile phone with Bluetooth technology to use the device
4. There are some variations in ECG obtained in winter and summer seasons, due to the fact of moisture of skin which acts as a conductor.

Studies using mobile applications

These devices used Kardia AliveCor for their studies.

1. Assessment of Remote Heart Rhythm Sampling Using the AliveCor Heart Monitor to Screen for Atrial Fibrillation The REHEARSE-AF Study
2. iTransmit study, a small ($n = 60$), single-center trial comparing conventional trans-telephonic monitoring to the Kardia Mobile device for monitoring patients for arrhythmia recurrence after the ablation procedure, the Kardia Mobile device had 100% sensitivity and 97% specificity in the detection of AF and atrial flutter
3. iHEART study: A single-center randomized, controlled trial investigating the efficacy of a mHealth ECG technology intervention to improve the detection of atrial fibrillation
4. ST LEUIS trial (ongoing) (Clinicaltrials.gov ID: NCT02498405), the authors showed that these reconstructed 12-lead ECGs from the Kardia Mobile device demonstrated excellent concordance with standard 12-lead ECGs for the detection of STEMI as well as non-STEMI.^[1]

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Conflicts of interest

There are no conflicts of interest.

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